

Analysis of eight binaries in Lyncis constellation: RV Lyn, AA Lyn, AH Lyn, CD Lyn, CF Lyn, DR Lyn, EK Lyn, and FS Lyn.

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Abstract

The available photometry mainly from the WASP database was used for the first light curve analysis of eight eclipsing binary systems located in the Lyncis constellation: RV Lyn, AA Lyn, AH Lyn, CD Lyn, CF Lyn, DR Lyn, EK Lyn, and FS Lyn. Most of these eclipsing stars are detached ones, having the orbital periods from 0.54 to 2.3 days. For the systems AA Lyn and CF Lyn a non-negligible third light was detected during the light curve solution. Moreover, 284 new times of minima for these binaries were derived, trying to identify the period variations. For the system CD Lyn a hypothetical third body was detected with the period of about 59 yr.

Key words: stars: binaries: eclipsing, stars: fundamental parameters

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1 Introduction

The crucial role of the eclipsing binaries in the nowadays astrophysics is evident. The eclipsing binary systems (hereafter EB) are being used for the most accurate determination of the basic parameters such as stellar masses and radii, as distance indicators, or can serve as classical celestial mechanics laboratories. Nowadays, we can even test the stellar structure models outside of our Galaxy, see e.g. Ribas (2004). Additionally, also the hidden components can be studied via the long term observations of the binaries as well as study the dynamical effects in such multiple systems (Rappaport et al., 2013). Due

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to all of these reasons the photometric monitoring and analysis of the light curves of selected eclipsing binaries still presents a fruitful contribution to the stellar astrophysics.

However, the available photometry for many interesting eclipsing binaries exists, but some of these EBs were still not analysed. Therefore, we decided to use mainly the Super WASP photometry (Pollacco et al., 2006) for a light curve analysis and derivation of new minima times for such systems, which were not studied before and their light curve solution is missing.

2 Analysis

The selection criteria for the binaries included in our study were rather straightforward. We focused on the unstudied systems in the constellation Lyncis. Only such binaries with known orbital periods were chosen, having no light curve solution published up to now, have enough data points for the analysis and also have several published times of minima. The last point was checked via an online archive of minima times observations, a so-called $O - C$ gateway¹, see Paschke & Brát (2006). Due to the very good time coverage provided by the Super WASP survey we used this database for the whole analysis of the light curve. All of the studied systems are located in the Lyncis constellations and are of moderate brightness ($9.3 \text{ mag} < V < 14.2 \text{ mag}$ in maximum) and with the orbital periods ranging from 0.54 to 2.3 days.

For the analysis of the light curve we used the PHOEBE program, ver. 0.31 (Prša & Zwitter, 2005), which is based on the algorithm by Wilson & Devinney (1971) and its later modifications. Due to having rather limited information about the stars, some of the parameters have to be fixed for the light curve (hereafter LC) solution. At first, the "Detached binary" mode (in Wilson & Devinney mode 2) was assumed for computing. If some of the components overfills its Roche lobe, we switched to some other configuration. The limb-darkening coefficients were interpolated from tables by van Hamme (see van Hamme 1993), and the linear cosine law was used. The values of the gravity brightening and bolometric albedo coefficients were set at their suggested values for convective or radiative atmospheres (see Lucy 1968). Therefore, the quantities which could be directly calculated from the LC are the following: the relative luminosities L_i , the temperature of the secondary T_2 , the inclination i , and the Kopal's modified potentials Ω_1 and Ω_2 . The synchronicity parameters F_1 and F_2 were also fixed at values of 1. The value of the additional third light contribution l_3 was also computed as a free parameter, which sometimes resulted in a non-negligible value. Its value cannot be directly compared

¹ <http://var.astro.cz/ocgate/>

with the two luminosities L_1 and L_2 , but it is being compared with the output fluxes l_1 and l_2 near the quadratures. And finally, the linear ephemerides were calculated using the available minima times for a particular system. For the LC modelling, the number of grid points on the components' surfaces were set to (40,30).

The problem with the mass ratio derivation arose in most of the studied systems. We started our analysis assuming the mass ratio $q = 1$, because no spectroscopy for these selected systems exists, and for detached EBs the LC solution is almost insensitive to the photometric mass ratio (see, e.g. Terrell & Wilson 2005). However, because for some systems this approach led to incorrect results, hence we used an alternative method of deriving the mass ratio following the method e.g. by Graczyk (2003). It uses the assumption that both components are located on the main sequence (which is necessarily not true) and the computed mass ratio is being directly derived from the individual luminosities. Therefore, having only limited information in photometry (one filter), some of the individual fitted parameters suffer from strong correlations between each other. Hence, we have to emphasize once again that the presented solution is still only very preliminary yet and only further spectroscopic observations of these systems will be able to reveal their true nature and the physical parameters with higher conclusiveness.

There also arises the problem with the primary temperature T_1 . This value has to be fixed during the whole computing process. When the spectral type is not available, the photometric indices were used for the rough estimation of the primary temperature (using the tables from Pecaut & Mamajek (2013) and the online web site²). However, for some of the systems this approach was not so straightforward due to the fact that for one star many different photometric indices exist, and moreover their interstellar reddening is not known. For the systems CD Lyn, CF Lyn, DR Lyn, EK Lyn, and FS Lyn some spectral estimations exist in the literature, while for RV Lyn, AA Lyn, and AH Lyn only the photometric indices are available. Hence, we collected all available indices and derived the particular spectral estimations. From these spectral types we eliminated the higher and lower outliers and from the rest some best value was estimated (or its upper value due to the unknown interstellar extinction).

With the final LC analysis, we also derived many times of minima for a particular system, using a method as presented in Zasche et al. (2014). The template of the LC was used to fit the photometric data from the Super WASP survey. This set of minima times was then combined with the already published minima mostly taken from the $O - C$ gateway (Paschke & Brát, 2006).

² http://www.pas.rochester.edu/~emamajek/EEM_dwarf_UBVIJHK_colors_Teff.txt

Table 1

The light-curve parameters as derived from our analysis.

Parameter	RV Lyn	AA Lyn	AH Lyn	CD Lyn
$JD_0 - 2400000$	54409.5592 ± 0.0005	54056.6671 ± 0.0008	54091.5447 ± 0.0010	54504.5198 ± 0.0004
P [d]	2.307640 ± 0.0000004	0.5613884 ± 0.0000003	1.01641142 ± 0.000008	2.2747194 ± 0.000008
i [deg]	84.91 ± 0.40	72.82 ± 0.46	88.75 ± 0.42	81.93 ± 0.70
$q = M_2/M_1$	0.69 ± 0.02	0.87 ± 0.04	0.86 ± 0.03	0.53 ± 0.04
Type	Detached	Semidetached	Detached	Detached
T_1 [K]	6700 (fixed)	5600 (fixed)	6500 (fixed)	6800 (fixed)
T_2 [K]	4287 ± 80	3760 ± 120	6074 ± 52	4350 ± 48
Ω_1	5.243 ± 0.081	4.984 ± 0.118	5.455 ± 0.037	4.946 ± 0.016
Ω_2	3.785 ± 0.024	3.535^b	5.588 ± 0.035	4.502 ± 0.013
$L_1/(L_1 + L_2)$ [%]	88.8 ± 1.3	86.3 ± 4.5	64.3 ± 1.3	94.4 ± 2.7
$L_2/(L_1 + L_2)$ [%]	11.2 ± 0.8	13.7 ± 1.3	35.7 ± 1.1	5.6 ± 2.1
l_3 [%] ^a	0.0	7.6 ± 2.1	0.0	0.0
R_1/a	0.210 ± 0.011	0.253 ± 0.021	0.219 ± 0.008	0.228 ± 0.040
R_2/a	0.268 ± 0.010	0.376 ± 0.018	0.191 ± 0.007	0.163 ± 0.031
Spot Lat. [deg]	–	–	–	84.7 ± 1.8
Spot Long. [deg]	–	–	–	328.8 ± 0.4
Spot Rad. [deg]	–	–	–	13.6 ± 1.2
Spot Temp.	–	–	–	0.82 ± 0.04

Note 1 ^a - given at the orbital phase of 0.25, ^b - not fitted during computation.

3 The individual systems

3.1 RV Lyn

The system RV Lyn (also 2MASS J06561142+5051455) is a typical system in our sample of stars. There were published only a few times of minima for this eclipsing binary and its orbital period of about 2.3 days is known. Nothing more about this system was published, no analysis of its light curve as well as no spectroscopic study can be found in published papers. We can only roughly estimate its spectral type from the color indices, hence we fixed the primary temperature at a value of 6700 K for the whole fitting process.

The Super WASP photometry revealed that it is a detached system, having very deep primary minimum (of about 2 magnitudes) and very shallow secondary one. Therefore, the PHOEBE code was used to fit the WASP data and the LC is presented in Fig. 1, while the LC parameters are given in Table 1. As one can see, both components are rather different from each other and the primary dominates with its luminosity in the system. No third light was detected in the LC solution.

Due to very shallow secondary minima, we used only the primary ones for the period analysis. Despite quite a lot WASP data points only three primary minima have been derived. The resulting $O - C$ diagram is shown in Fig. 2. We can see there that some long-period modulation of the orbital period is probably present in the system. This can naturally be explained by the mass transfer between the components, but only further investigation would be able

to prove this hypothesis.

3.2 *AA Lyn*

The eclipsing binary AA Lyn (also 2MASS J07504631+4134065) is rather faint star, which was also not studied before. Kinman et al. (1982) included the star into their survey of RR Lyrae stars, but with the note that it is an eclipsing binary with the period of about 0.56 days. Since then no analysis of AA Lyn was carried out.

For the LC fitting we assumed the primary temperature to be of 5600 K (it is the coolest star in our sample) and used the WASP photometry for the LC analysis. The result is plotted in Fig. 3, and the LC parameters as resulted from PHOEBE are given in Table 1. This is the only system which resulted in semidetached configuration. One can see that the primary is the dominant source in the system, but there also arose a non-negligible contribution of the third light. However, its origin is still questionable because there are two close companions to AA Lyn (see Bonnarel et al. 2000) at the distances of a few arcseconds only.

Because of shallow secondary minimum, only the primary ones were used for a period analysis. In our Fig. 4 there are plotted the new times of minima together with the already published ones. Obviously, there is no variation in the times of minima, or our dataset is still too poor for any such detection.

3.3 *AH Lyn*

The system AH Lyn (also 2MASS J08421824+3711051) is the binary which was also not studied before, therefore we included it into our sample of stars. AH Lyn was included into the study of RR Lyrae stars (Kinman et al., 1982) like AA Lyn and the authors correctly derived its orbital period to be of about 1.016 days. Since then only several publications with the times of minima were published.

For the light curve analysis we fixed the primary temperature to $T_1 = 6500$ K in agreement with the photometric indices of the star. The WASP photometry shows us that both the eclipses are rather deep and symmetrically shaped. The final parameters of the LC fitting are given in Table 1, while the LC plot is shown in Fig. 5. The system is well detached, both components are rather similar to each other, and no third light was detected in the LC solution.

For the period analysis we derived 60 new minima times (both primary and

secondary) from the WASP data covering almost 500 days. With the already published ones the complete dataset is plotted in Fig. 6, but no visible variation can be seen there.

3.4 *CD Lyn*

The star named CD Lyn (also HIP 37615) is relatively bright star, and it is also the most frequently studied one. There exist two dedicated studies on CD Lyncis, Baldwin et al. (2000) and Meyer (2002), but these are only remarks on their observations of CD Lyn photometrically, with no LC analysis. Moreover, Baldwin et al. (2000) presented the orbital period of 4.549 days, abandoning the original 2.27 days period, arguing that there is no curvature near the quadrature. But as we can see from our analysis, the correct period is 2.27 days for sure.

The LC fitting of the Super WASP data using the PHOEBE programme was using the assumption of $T_1 = 6800$ K, because its spectral type was derived as F2 by Hill & Schilt (1952). The final fit of the LC is given in Fig. 7, and the LC parameters are written in Table 1. As one can see, the secondary minima have much less depth, but definitely cannot be taken as a noise. Hence, the main finding as published by Baldwin et al. (2000) has to be reconsidered. Another interesting finding about this star is the asymmetric shape of its light curve, hence we have to use a hypothesis of a star spot on the surface of primary (see Fig. 9). However, it seems like the shape of the LC is changing in time, maybe due to the moving spot or some other photospheric activity of the star(s).

The period analysis of CD Lyn was done using the already published data as well as our new data points (altogether eight new primary minima from the WASP survey). The result is shown in Fig. 8, where we also used the hypothesis of the third body orbiting around a common barycenter with the eclipsing pair (see e.g. Irwin 1959 or Mayer 1990). This approach was used because it produces much better result than the linear or quadratic ephemerides term for description of the period variation. The variation of such a component has the period of about 59 years and the amplitude of about 0.03 days in the $O - C$ diagram. From our LITE fit we also predicted that such a body should present at least of about 2.5% of the total luminosity, but our LC solution results in zero value. Therefore, for a final confirmation of any such body in the system one needs much more data, so our presented solution is still just a hypothesis yet.

Table 2

The light-curve parameters as derived from our analysis.

Parameter	CF Lyn	DR Lyn	EK Lyn	FS Lyn
$JD_0 - 2400000$	54069.6974 ± 0.0007	54502.5720 ± 0.0026	54068.6844 ± 0.0005	54142.4354 ± 0.0003
P [d]	1.3853727 ± 0.0000029	1.7808806 ± 0.0000011	2.2355353 ± 0.000093	0.5400052 ± 0.0000030
i [deg]	86.31 ± 0.79	85.96 ± 0.69	83.13 ± 0.98	63.50 ± 0.94
$q = M_2/M_1$	0.85 ± 0.06	0.74 ± 0.02	0.42 ± 0.03	0.71 ± 0.09
Type	Detached	Detached	Detached	Detached
T_1 [K]	6150 (fixed)	6690 (fixed)	8840 (fixed)	7100 (fixed)
T_2 [K]	5100 ± 72	4370 ± 72	5325 ± 110	5019 ± 66
Ω_1	4.209 ± 0.022	5.100 ± 0.027	4.828 ± 0.040	3.292 ± 0.025
Ω_2	7.269 ± 0.046	3.580 ± 0.010	4.533 ± 0.027	3.297 ± 0.029
$L_1/(L_1 + L_2)$ [%]	92.5 ± 0.8	84.6 ± 0.8	96.9 ± 3.7	87.2 ± 1.7
$L_2/(L_1 + L_2)$ [%]	7.5 ± 0.3	15.4 ± 0.4	3.1 ± 1.2	12.8 ± 0.9
l_3 [%] ^a	18.1 ± 1.0	0.0	3.7 ± 0.7	0.0
R_1/a	0.305 ± 0.012	0.231 ± 0.011	0.228 ± 0.021	0.402 ± 0.027
R_2/a	0.140 ± 0.009	0.310 ± 0.008	0.127 ± 0.034	0.342 ± 0.024

Note 2 ^a - given at the orbital phase of 0.25

3.5 CF Lyn

Another rather bright target is CF Lyn (also HIP 37748), which has the orbital period of about 1.4 days, but was also not studied in detail neither photometrically, nor spectroscopically. Only its spectral type was classified as F8 by Heckmann (1975).

We used the WASP photometry for the light curve modelling and the assumption of the 6150 K for the primary temperature. As we can see from Fig. 10, the star has relatively shallow total eclipses, which could indicate large fraction of the third light and inclination close to 90° . For this system we also tried a different approach for the analysis. Due to its significant curvature outside of eclipses we also tried to fit the mass ratio q as a free parameter despite its detached configuration. This result was then compared with the result as obtained via a standard method of q estimation by a Graczyk's method. And both q parameters resulted in rather similar values of about 0.85 and 0.83, respectively. All the parameters of our LC fitting are given in Table 2 (a solution with fitted q is presented). Rather significant value of the third light resulted, indicating possible presence of the third component in the system. Noticeable is also some light curve variability over the Super WASP data period.

Concerning the period analysis we collected only the three minima as presented in the $O - C$ gateway (Paschke & Brát, 2006) and together with our 33 new times of minima, we have the coverage over almost 20 years of data. However, even on this dataset there is no evident variation of the period, see Fig. 11.

3.6 *DR Lyn*

The star DR Lyn (also TYC 3421-2216-1) is another Algol-type eclipsing binary in our sample of stars. No detailed study about this star was found in the published papers, only three times of minima were published till yet. These minima gave the orbital period of about 1.78 days. The star was also included into the survey of LAMOST (Luo et al., 2015), yielding its spectral type of about F3 and the primary temperature to be 6690 K.

With this assumed temperature we performed the light curve analysis of the WASP data. The light curve shape plotted in Fig. 12 shows very deep primary minimum (more than 2 magnitudes) and rather shallow secondary one. It indicates quite different components in the eclipsing pair. The results of the LC modelling are given in Table 2. The components are well detached, but rather different from each other.

For the period analysis we collected the already published data points (i.e. only three times of minima) together with our new ones from the WASP survey (i.e. 19 new minima). With this dataset we carried out the analysis, but no periodic signal was found, see our Fig. 13.

3.7 *EK Lyn*

The star EK Lyn (also TYC 2973-339-1) is the brightest target in our sample, having the orbital period of about 2.23 days. Despite its high luminosity, only very little is known about this star. The only relevant information is that one by Heckmann (1975) that the spectral type is of A2, hence it is the system of the earliest spectral type in our sample of stars.

For the light curve analysis we fixed the primary temperature to 8840 K (in agreement with Pecaut & Mamajek 2013). The shape of the LC is changing in time, hence its modelling was not straightforward. The parameters of our LC fit are given in Table 2, where we can see that the primary component dominates the system and no third light was detected. The fit is also plotted in Fig. 14.

Analysis of the period changes was done using the two published minima together with our new 13 data points. The result is shown in Fig. 15. No visible variation can be seen there, but the data set is still rather limited yet. The most recent minima deviate a bit from the linear ephemerides, but only further investigation would prove any such variation. What is quite surprising is the fact that the time of minimum published by Diethelm (2012) deviates of about 0.5 days from our ephemerides and is probably incorrect (we have

not plotted this one data point in our Fig. 15).

3.8 *FS Lyn*

The eclipsing system FS Lyn (also TYC 2986-534-1) is the only one system in our study, which was classified as a β -Lyrae type star (Maciejewski & Niedzielski, 2005). However, despite its short period (0.54 days) and relatively high brightness (11 mag) it was not studied before.

For the LC modelling we used the assumption that the star is of about F2 spectral type, i.e. the primary temperature was fixed at a value of 7100 K, see Ammons et al. (2006). Performing the LC modelling, we obtained a solution with a detached configuration (near contact, but both semidetached and contact configurations were tested but produced slightly worse fits). Due to its shape of the light curve, we also tried to compute the mass ratio as a free parameter. There resulted that the q values from the classical approach of Graczyk and that one fitted are not so different from each other (0.71 fitted, while 0.64 estimated from the mass-luminosity relation method by Graczyk 2003). The resulting parameters are given in Table 2, while the fit itself is plotted in Fig. 16.

For the analysis of its orbital period we derived from the WASP data 107 minima in total. With the two already published ones the complete data set covers about 8 years, see Fig. 17. However, no variation is visible on these data and the linear ephemerides are sufficient for prospective future observations.

4 Discussion and conclusions

The very first LC solution for eight Algol-type eclipsing binaries (based on the Super WASP photometry) led to several findings:

- The photometry based on the Super WASP survey data can be used for a fruitful analysis for the eclipsing binaries never studied before.
- Second-order effects such as the third light or the spots, are also detectable in these data.
- For two of the systems (AA Lyn, and CF Lyn) the amount of the third light is large enough that these cannot easily be considered as pure binaries in any future more detailed study.
- The method of using the light curve templates for deriving the times of minima provides us with reliable and sufficiently precise times of minima suitable for a period analysis.

- For the system RV Lyn we found a steady period increase (probably due to mass transfer), while for the system CD Lyn there was detected some period modulation in the $O - C$ diagram. This variation with the period of about 59 years can be attributed to a prospective third body in the system.

All of the presented systems have not been studied before concerning their light curves, hence we can consider this study as a good starting point for a future more detailed analysis. Particularly, a special focus should be taken to these systems, where a larger fraction of the third light was detected and the system, where a third body variation in the $O - C$ diagram was found.

5 Acknowledgments

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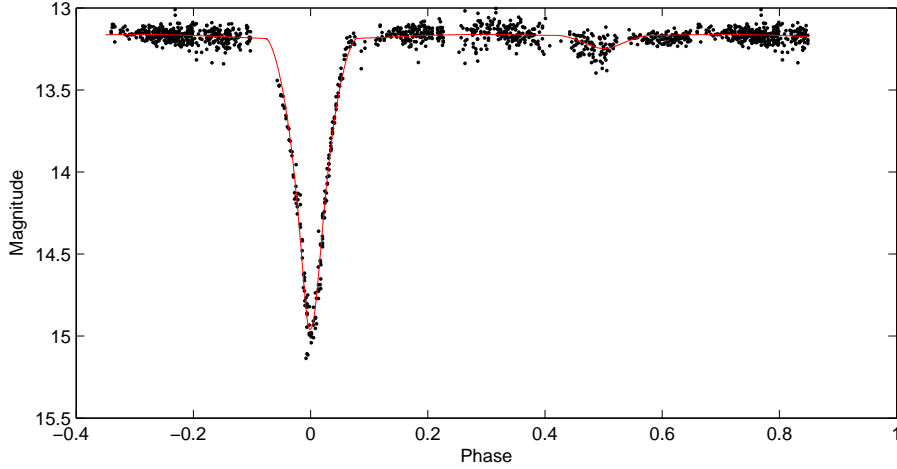


Fig. 1. Light curve analysis of RV Lyn, based on the Super WASP photometry.

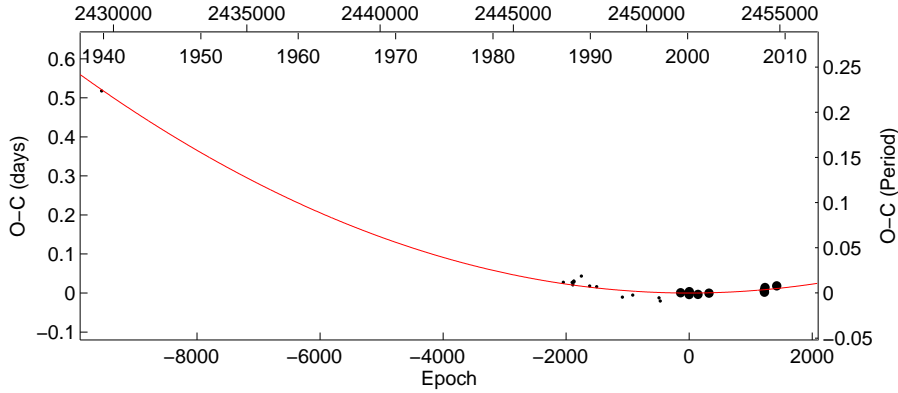


Fig. 2. O-C diagram of times of minima for RV Lyn. The black points stand for the primary minima, the larger the symbol, the higher the weight. The red line represents the quadratic term in the ephemerides.

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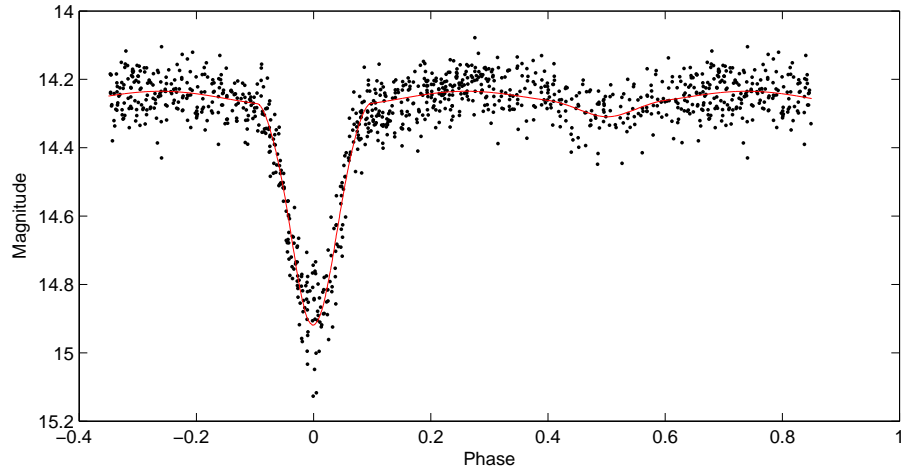


Fig. 3. Light curve analysis of AA Lyn, based on the Super WASP photometry.

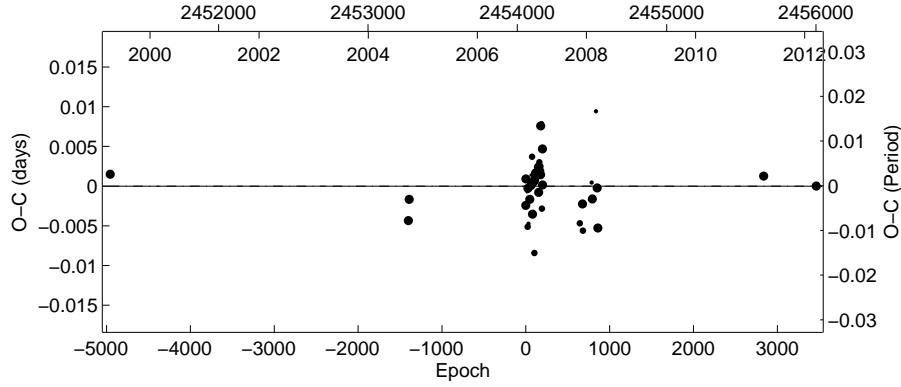


Fig. 4. O-C diagram of times of minima for AA Lyn.

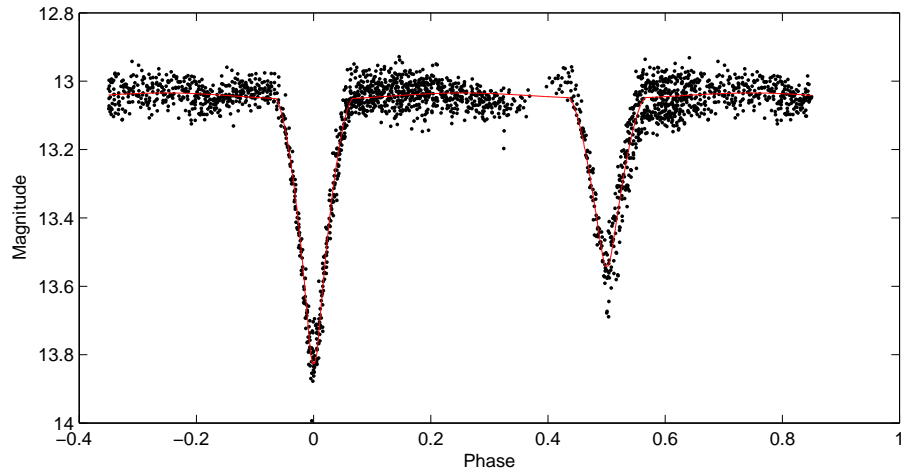


Fig. 5. Light curve analysis of AH Lyn, based on the Super WASP photometry.

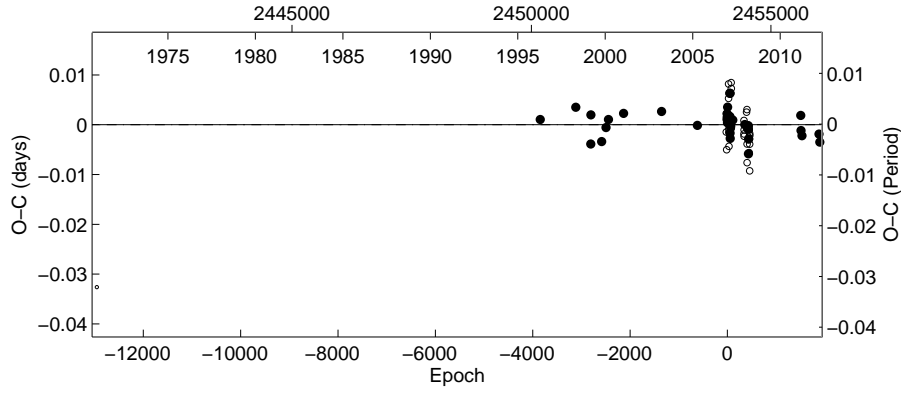


Fig. 6. O-C diagram of times of minima for AH Lyn. The secondary minima are plotted as open circles.

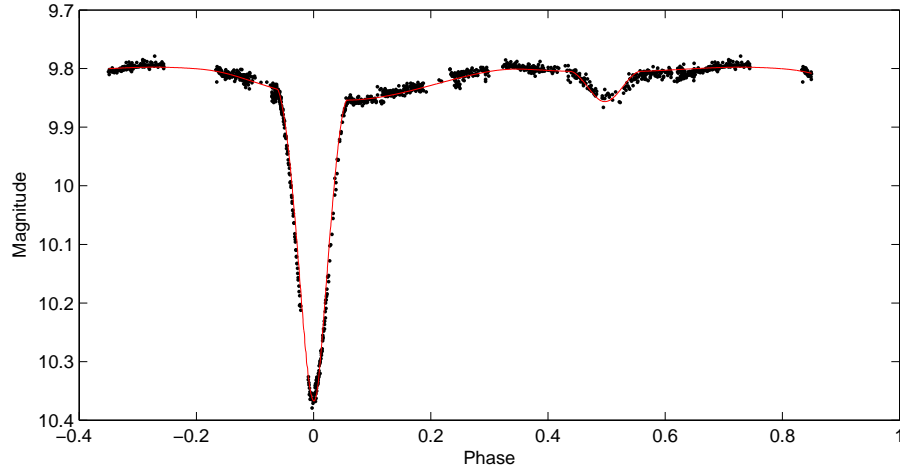


Fig. 7. Light curve analysis of CD Lyn, based on the Super WASP photometry.

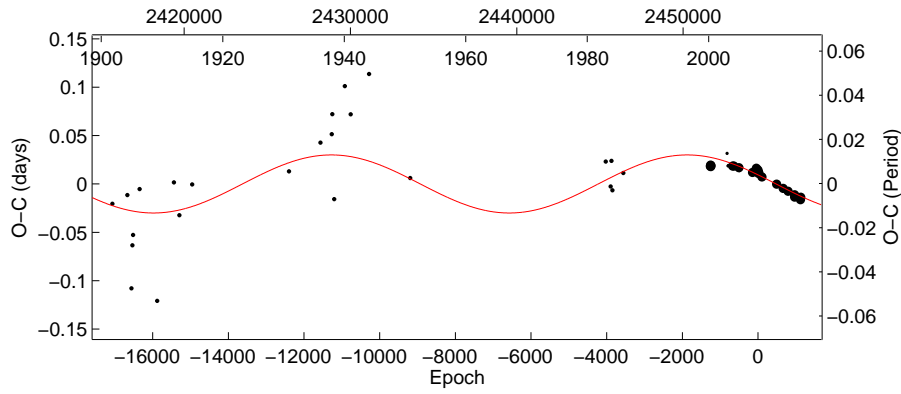


Fig. 8. O-C diagram of times of minima for CD Lyn.



Fig. 9. 3D plot of CD Lyn, cross stands for the barycenter of the system.

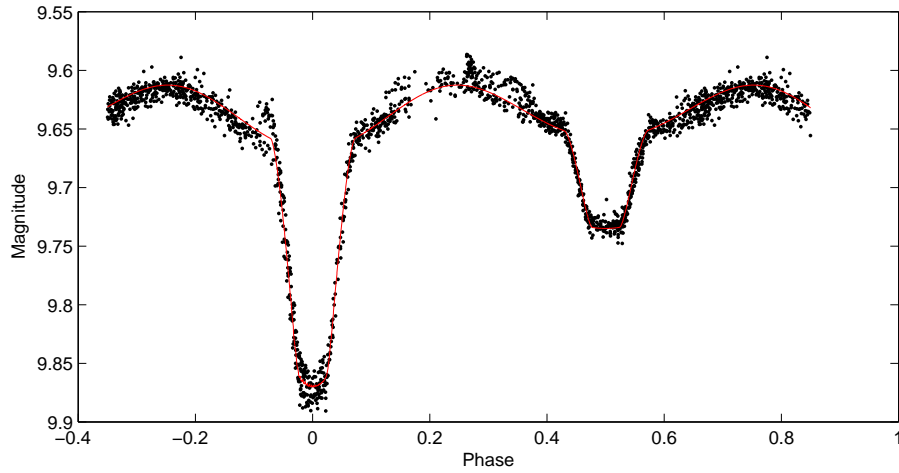


Fig. 10. Light curve analysis of CF Lyn, based on the Super WASP photometry.

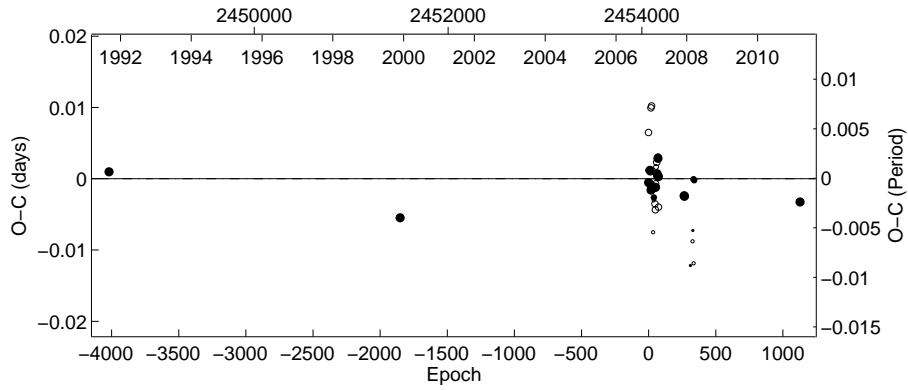


Fig. 11. O-C diagram of times of minima for CF Lyn.

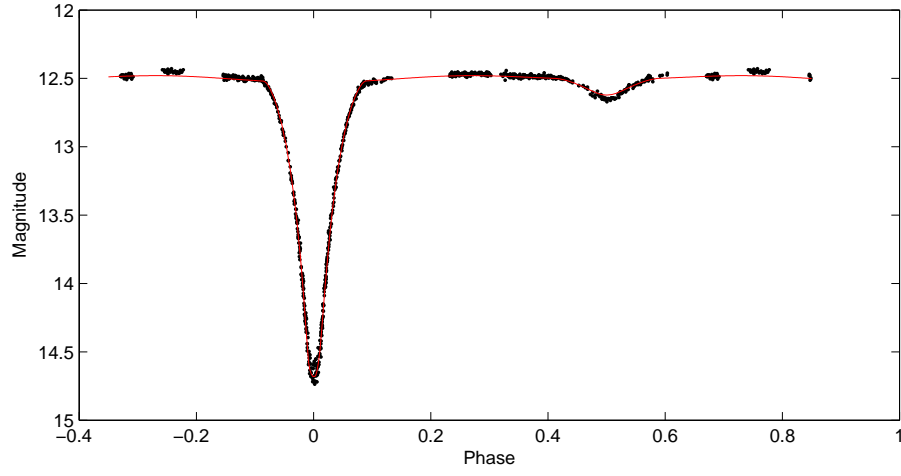


Fig. 12. Light curve analysis of DR Lyn, based on the Super WASP photometry.

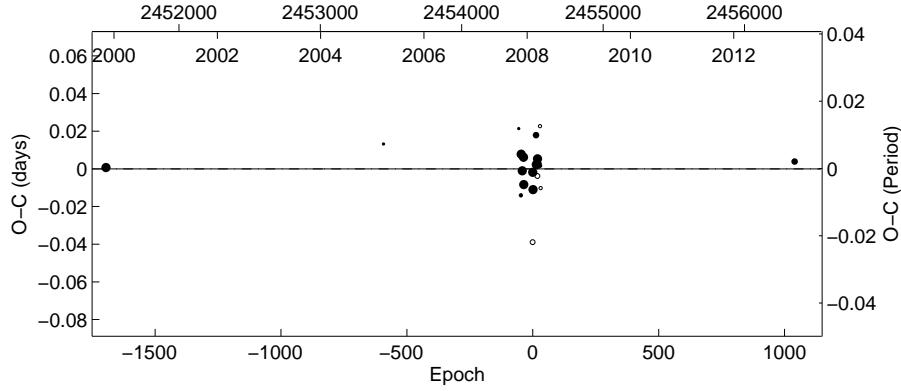


Fig. 13. O-C diagram of times of minima for DR Lyn.

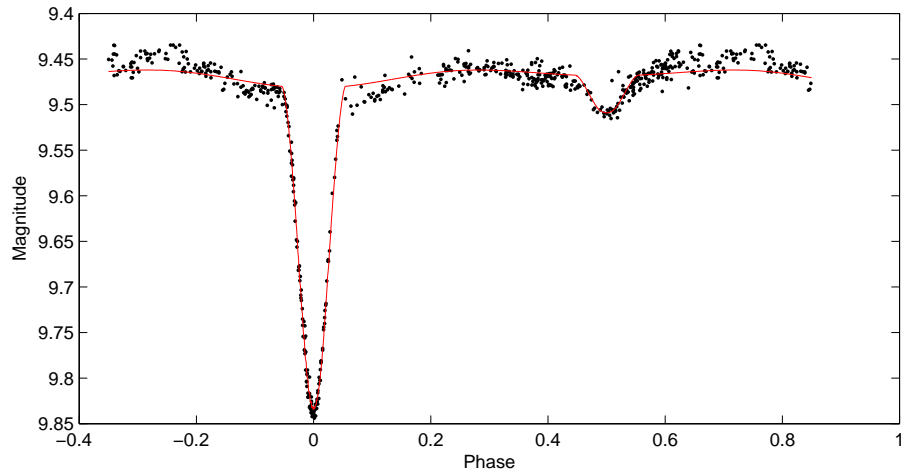


Fig. 14. Light curve analysis of EK Lyn, based on the Super WASP photometry.

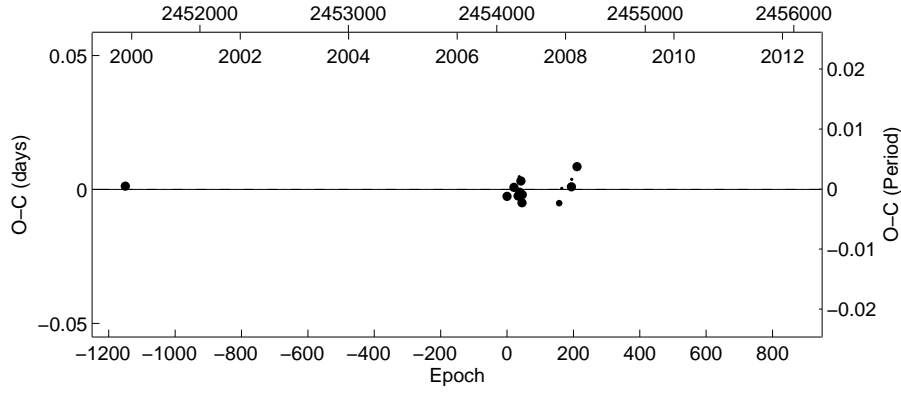


Fig. 15. O-C diagram of times of minima for EK Lyn.

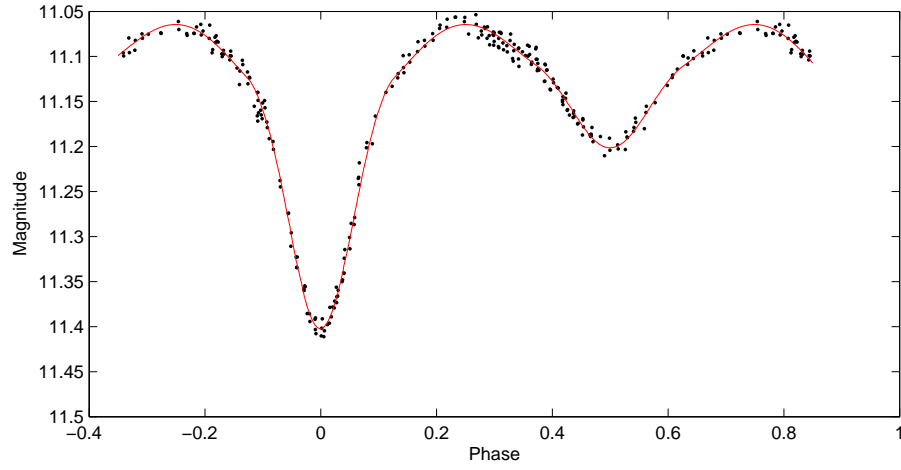


Fig. 16. Light curve analysis of FS Lyn, based on the Super WASP photometry.

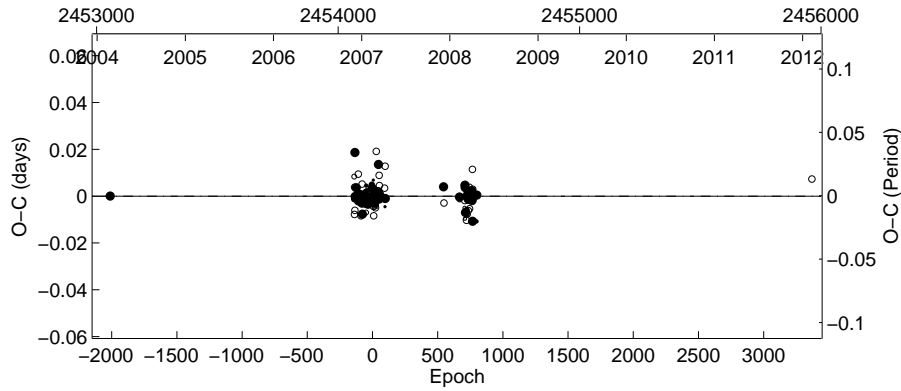


Fig. 17. O-C diagram of times of minima for FS Lyn.

Table 3
New Super WASP heliocentric minima times for the studied systems.

Star	HJD	Error	Type	Star	HJD	Error	Type	Star	HJD	Error	Type	Star	HJD	Error	Type
	2400000+	[days]			2400000+	[days]			2400000+	[days]			2400000+	[days]	
RV Lyn	54409.55525	0.00107	Pri	AH Lyn	54148.46471	0.00062	Pri	CF Lyn	54532.41182	0.00035	Pri	FS Lyn	54140.54703	0.00024	Sec
RV Lyn	54418.78147	0.00105	Pri	AH Lyn	54149.47737	0.00066	Pri	CF Lyn	54534.47809	0.00025	Sec	FS Lyn	54141.35882	0.00040	Pri
RV Lyn	54439.56228	0.01397	Pri	AH Lyn	54150.49752	0.00053	Pri	CF Lyn	54539.33855	0.00140	Pri	FS Lyn	54141.62519	0.00046	Sec
AA Lyn	53270.71845	0.00081	Pri	AH Lyn	54153.54617	0.00035	Pri	DR Lyn	54402.86409	0.00187	Pri	FS Lyn	54142.43395	0.00005	Pri
AA Lyn	53275.77618	0.00080	Pri	AH Lyn	54154.56193	0.00057	Pri	DR Lyn	54418.85657	0.00280	Pri	FS Lyn	54143.51490	0.00036	Pri
AA Lyn	54056.66579	0.00044	Pri	AH Lyn	54155.57885	0.00035	Pri	DR Lyn	54420.65931	0.00107	Pri	FS Lyn	54145.40421	0.00039	Sec
AA Lyn	54057.78959	0.00033	Pri	AH Lyn	54156.59493	0.00035	Pri	DR Lyn	54427.77398	0.00013	Pri	FS Lyn	54145.68229	0.00032	Pri
AA Lyn	54066.77067	0.00043	Pri	AH Lyn	54157.61106	0.00055	Pri	DR Lyn	54436.68563	0.00051	Pri	FS Lyn	54146.48110	0.00026	Sec
AA Lyn	54069.57356	0.00037	Pri	AH Lyn	54169.29889	0.00051	Sec	DR Lyn	54437.57588	0.00023	Sec	FS Lyn	54146.75387	0.00068	Pri
AA Lyn	54070.70159	0.00047	Pri	AH Lyn	54170.32503	0.00014	Sec	DR Lyn	54438.45196	0.00212	Pri	FS Lyn	54147.55707	0.00074	Sec
AA Lyn	54074.62396	0.00048	Pri	AH Lyn	54171.34025	0.00043	Sec	DR Lyn	54501.64267	0.00101	Sec	FS Lyn	54149.45652	0.00017	Pri
AA Lyn	54083.61287	0.00061	Pri	AH Lyn	54172.34865	0.00103	Sec	DR Lyn	54502.57016	0.00046	Pri	FS Lyn	54150.53247	0.00021	Pri
AA Lyn	54084.73688	0.00021	Pri	AH Lyn	54436.61451	0.00041	Sec	DR Lyn	54504.34187	0.00009	Pri	FS Lyn	54152.42491	0.00041	Sec
AA Lyn	54091.47474	0.00317	Pri	AH Lyn	54437.63363	0.00047	Sec	DR Lyn	54525.74135	0.00142	Pri	FS Lyn	54153.50144	0.00039	Sec
AA Lyn	54092.59556	0.00061	Pri	AH Lyn	54438.64814	0.00032	Sec	DR Lyn	54526.61569	0.00156	Sec	FS Lyn	54154.31478	0.00050	Pri
AA Lyn	54098.77504	0.00032	Pri	AH Lyn	54439.66328	0.00065	Sec	DR Lyn	54527.50664	0.00038	Pri	FS Lyn	54154.58056	0.00026	Sec
AA Lyn	54101.57519	0.00043	Pri	AH Lyn	54491.50509	0.00073	Sec	DR Lyn	54534.63023	0.00073	Pri	FS Lyn	54155.39500	0.00018	Pri
AA Lyn	54111.68277	0.00041	Pri	AH Lyn	54500.65333	0.00087	Sec	DR Lyn	54535.51456	0.00194	Sec	FS Lyn	54155.66530	0.00031	Sec
AA Lyn	54114.48227	0.00048	Pri	AH Lyn	54501.65906	0.00054	Sec	DR Lyn	54536.41409	0.00005	Pri	FS Lyn	54156.47532	0.00029	Pri
AA Lyn	54115.61175	0.00073	Pri	AH Lyn	54502.67922	0.00068	Sec	DR Lyn	54553.34978	0.00200	Sec	FS Lyn	54157.28157	0.00005	Sec
AA Lyn	54120.66564	0.00043	Pri	AH Lyn	54524.53568	0.00029	Pri	DR Lyn	54554.21918	0.00129	Pri	FS Lyn	54157.55467	0.00006	Pri
AA Lyn	54123.47307	0.00046	Pri	AH Lyn	54526.56859	0.00102	Pri	DR Lyn	54558.65951	0.00206	Sec	FS Lyn	54158.38473	0.00033	Sec
AA Lyn	54141.43916	0.00062	Pri	AH Lyn	54527.58434	0.00053	Pri	EK Lyn	54068.68182	0.00046	Pri	FS Lyn	54163.49561	0.00027	Pri
AA Lyn	54142.55899	0.00096	Pri	AH Lyn	54530.62859	0.00035	Pri	EK Lyn	54115.63139	0.00117	Pri	FS Lyn	54165.38702	0.00039	Sec
AA Lyn	54145.36689	0.00044	Pri	AH Lyn	54532.66436	0.00095	Pri	EK Lyn	54142.45463	0.00112	Pri	FS Lyn	54165.65760	0.00022	Sec
AA Lyn	54146.49071	0.00089	Pri	AH Lyn	54539.27137	0.00175	Sec	EK Lyn	54151.40394	0.00200	Pri	FS Lyn	54166.46405	0.00043	Pri
AA Lyn	54147.61472	0.00101	Pri	AH Lyn	54544.35038	0.00026	Sec	EK Lyn	54153.63369	0.00042	Pri	FS Lyn	54167.28921	0.00022	Pri
AA Lyn	54150.42093	0.00019	Pri	AH Lyn	54547.40413	0.00051	Sec	EK Lyn	54162.58002	0.00096	Pri	FS Lyn	54167.54646	0.00041	Sec
AA Lyn	54154.34954	0.00026	Pri	AH Lyn	54553.50085	0.00055	Sec	EK Lyn	54169.27849	0.00278	Pri	FS Lyn	54168.35674	0.00022	Pri
AA Lyn	54155.47350	0.00039	Pri	AH Lyn	54555.53473	0.00071	Sec	EK Lyn	54171.51703	0.00041	Pri	FS Lyn	54169.43560	0.00034	Pri
AA Lyn	54156.60471	0.00042	Pri	AH Lyn	54556.54901	0.00043	Sec	EK Lyn	54419.65832	0.00175	Pri	FS Lyn	54170.25455	0.00048	Sec
AA Lyn	54163.33927	0.00062	Pri	AH Lyn	54557.56006	0.00393	Sec	EK Lyn	54437.54808	0.00451	Pri	FS Lyn	54170.51449	0.00039	Pri
AA Lyn	54164.45003	0.00046	Pri	AH Lyn	54558.58358	0.00149	Sec	EK Lyn	54502.37924	0.00020	Pri	FS Lyn	54171.33025	0.00022	Sec
AA Lyn	54168.38779	0.00054	Pri	CD Lyn	54406.71262	0.00123	Pri	EK Lyn	54504.61757	0.00196	Pri	FS Lyn	54171.59637	0.00048	Pri
AA Lyn	54169.50637	0.00034	Pri	CD Lyn	54438.55591	0.00128	Pri	EK Lyn	54540.39085	0.00220	Pri	FS Lyn	54172.40493	0.00037	Sec
AA Lyn	54181.75738	0.00066	Pri	CD Lyn	54447.65708	0.00219	Pri	FS Lyn	54066.57305	0.00031	Sec	FS Lyn	54192.38935	0.00035	Sec
AA Lyn	54436.72370	0.00061	Pri	CD Lyn	54504.52460	0.00028	Pri	FS Lyn	54066.83345	0.00014	Pri	FS Lyn	54194.27141	0.00053	Pri
AA Lyn	54439.53016	0.00052	Pri	CD Lyn	54527.26939	0.00108	Pri	FS Lyn	54067.63690	0.00051	Sec	FS Lyn	54194.55869	0.00047	Sec
AA Lyn	54497.35876	0.00038	Pri	CD Lyn	54536.36740	0.00074	Pri	FS Lyn	54068.72856	0.00029	Sec	FS Lyn	54195.35491	0.00005	Pri
AA Lyn	54502.40768	0.00043	Pri	CD Lyn	54545.46518	0.00068	Pri	FS Lyn	54069.55337	0.00068	Pri	FS Lyn	54436.74227	0.00049	Pri
AA Lyn	54503.52984	0.00041	Pri	CD Lyn	54554.56601	0.00434	Pri	FS Lyn	54069.79863	0.00031	Sec	FS Lyn	54438.62536	0.00015	Sec
AA Lyn	54526.55566	0.00064	Pri	CF Lyn	54056.53756	0.00038	Sec	FS Lyn	54070.61459	0.00080	Pri	FS Lyn	54502.61854	0.00009	Pri
AA Lyn	54534.40878	0.00018	Pri	CF Lyn	54067.62583	0.00149	Sec	FS Lyn	54075.47837	0.00061	Pri	FS Lyn	54503.42752	0.00064	Sec
AA Lyn	54539.45969	0.00065	Pri	CF Lyn	54069.69686	0.00041	Pri	FS Lyn	54075.74400	0.00036	Sec	FS Lyn	54523.40408	0.00022	Sec
AH Lyn	54066.64114	0.00078	Sec	CF Lyn	54083.55231	0.00073	Pri	FS Lyn	54083.57324	0.00041	Pri	FS Lyn	54524.48726	0.00010	Sec
AH Lyn	54067.66001	0.00005	Sec	CF Lyn	54085.63016	0.00069	Sec	FS Lyn	54083.85424	0.00028	Sec	FS Lyn	54525.30379	0.00012	Pri
AH Lyn	54068.67771	0.00031	Sec	CF Lyn	54092.56599	0.00092	Sec	FS Lyn	54084.65282	0.00016	Pri	FS Lyn	54525.55949	0.00026	Sec
AH Lyn	54069.69312	0.00014	Sec	CF Lyn	54094.63253	0.00050	Pri	FS Lyn	54085.73491	0.00020	Pri	FS Lyn	54526.38279	0.00013	Pri
AH Lyn	54070.70987	0.00036	Sec	CF Lyn	54098.78925	0.00076	Pri	FS Lyn	54091.67340	0.00032	Pri	FS Lyn	54527.45214	0.00053	Pri
AH Lyn	54074.77496	0.00071	Sec	CF Lyn	54099.49312	0.00115	Sec	FS Lyn	54092.75563	0.00062	Pri	FS Lyn	54531.49885	0.00038	Sec
AH Lyn	54075.78529	0.00091	Sec	CF Lyn	54101.55962	0.00048	Pri	FS Lyn	54094.63657	0.00037	Sec	FS Lyn	54532.31317	0.00015	Pri
AH Lyn	54091.54683	0.00007	Pri	CF Lyn	54114.71451	0.00240	Sec	FS Lyn	54098.69201	0.00027	Pri	FS Lyn	54532.58127	0.00005	Sec
AH Lyn	54092.56149	0.00110	Pri	CF Lyn	54121.64584	0.00143	Sec	FS Lyn	54099.51019	0.00044	Sec	FS Lyn	54535.55866	0.00041	Pri
AH Lyn	54094.59746	0.00077	Pri	CF Lyn	54123.72430	0.00208	Pri	FS Lyn	54099.77514	0.00031	Pri	FS Lyn	54536.36826	0.00048	Sec
AH Lyn	54098.66150	0.00025	Pri	CF Lyn	54135.49908	0.00011	Sec	FS Lyn	54100.57688	0.00064	Sec	FS Lyn	54536.63994	0.00035	Pri
AH Lyn	54099.67648	0.00061	Pri	CF Lyn	54139.65437	0.00059	Sec	FS Lyn	54100.84732	0.00021	Pri	FS Lyn	54537.44138	0.00020	Sec
AH Lyn	54100.69420	0.00030	Pri	CF Lyn	54140.35021	0.00040	Pri	FS Lyn	54101.66338	0.00039	Sec	FS Lyn	54539.33791	0.00020	Pri
AH Lyn	54101.71020	0.00023	Pri	CF Lyn	54142.42875	0.00110	Sec	FS Lyn	54111.65288	0.00054	Pri	FS Lyn	54539.60308	0.00019	Sec
AH Lyn	54115.43563	0.00146	Sec	CF Lyn	54146.58725	0.00099	Sec	FS Lyn	54114.62174	0.00039	Sec	FS Lyn	54540.41809	0.00058	Pri
AH Lyn	54116.45495	0.00091	Sec	CF Lyn	54153.51475	0.00078	Sec	FS Lyn	54115.43699	0.00060	Pri	FS Lyn	54541.49754	0.00015	Pri
AH Lyn	54118.47987	0.00080	Sec	CF Lyn	54155.59123	0.00005	Pri	FS Lyn	54115.69815	0.00043	Sec	FS Lyn	54544.46391	0.00033	Sec
AH Lyn	54120.51090	0.00077	Sec	CF Lyn	54162.51781	0.00027	Pri	FS Lyn	54116.51968	0.00032	Pri	FS Lyn	54545.55342	0.00022	Sec
AH Lyn	54121.53030	0.00063	Sec	CF Lyn	54165.29099	0.00056	Pri	FS Lyn	54118.40445	0.00039	Sec	FS Lyn	54553.38163	0.00051	Pri
AH Lyn	54122.54438	0.00104	Sec	CF Lyn	54167.36922	0.00088	Sec	FS Lyn	54118.67406	0.00020	Pri	FS Lyn	54554.45754	0.00034	Pri
AH Lyn	54123.55731	0.00088	Sec	CF Lyn	54169.44452	0.00084	Sec	FS Lyn	54120.56704	0.00031	Sec	FS Lyn	54555.54059	0.00028	Pri
AH Lyn	54141.35516	0.00011	Pri	CF Lyn	54171.51833	0.00071	Sec	FS Lyn	54121.64454	0.00037	Sec	FS Lyn	54556.36089	0.00005	Sec
AH Lyn	54142.37156	0.00069	Pri	CF Lyn	54436.81879	0.00028	Pri	FS Lyn	54122.45438	0.00045	Pri	FS Lyn	54556.60870	0.00082	Pri
AH Lyn	54143.38332	0.00053	Pri	CF Lyn	54439.58947	0.00091	Pri	FS Lyn	54122.72509	0.00054	Sec	FS Lyn	54557.43236	0.00048	Sec
AH Lyn	54145.41546	0.00061	Pri	CF Lyn	54500.53616	0.00077	Pri	FS Lyn	54123.53178	0.00011	Pri	FS Lyn	54558.50803	0.00046	Sec
AH Lyn	54146.43718	0.00048	Pri	CF Lyn	54523.39820	0.00052	Sec	FS Lyn	54139.46764	0.00043	Sec	FS Lyn	54573.34878	0.00028	Pri
AH Lyn	54147.44563	0.00021	Pri	CF Lyn	54525.47777	0.00105	Pri	FS Lyn	54139.74027	0.00051	Pri	FS Lyn	54574.44005	0.00023	Pri